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Grassland management, forage production and plant biodiversity in a Mediterranean grazing system

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Abstract. Mediterranean grazing systems have strongly affected the vegetation dynamics and grassland flora's composition at landscape scale. The aim of this study was to evaluate the impact of different management systems on forage production and plant biodiversity of grasslands in agro-pastoral farms of the dehesa landscape of North-eastern Sardinia. Sampling areas were located in grasslands characterized by different grazing system typologies (cattle and sheep), and by different type of soil management (short, medium and long rotation with forage crops). The effects of grazing animal species and type of agronomic management were evaluated. Agronomical and floristic data collected throughout the year allowed to assess herbage mass and herbage on offer seasonal dynamics, botanical composition and biodiversity indicators (Species Richness and Shannon's Index). In late spring, herbage mass and herbage on offer showed differences between types of grassland management. Grazing system typologies significantly influenced floristic composition but not the plant biodiversity indices.

Keywords. Pastures – Tillage – Grazing management – Sardinia.

Gestion des prairies, production de fourrage et biodiversité végétale dans un système d'élevage méditerranéen

Résumé. *Les activités agropastorales méditerranéennes ont fortement influencé la dynamique de la végétation et la composition floristique des prairies à l'échelle de paysage. Le but de ce projet de recherche était d'évaluer les effets des divers systèmes de gestion sur la production de fourrage et la biodiversité végétale dans les exploitations agropastorales qui se trouvent dans le paysage de la dehesa, dans le nord-est de la Sardaigne. Les zones échantillon individuées sont des pâturages caractérisés par des élevages de diverses espèces (ovins et bovins) et par une différente gestion agronomique des pâturages (court, moyen et long assolement avec culture de fourrage). On a évalué l'influence des espèces animales pâturant et de la typologie de gestion agronomique. Les données agronomiques et de la végétation collectées pendant l'année ont permis d'évaluer la croissance de la végétation, sa disponibilité dans les champs pâturés, les dynamiques saisonnières, la composition botanique et les mesures de la biodiversité (Richesse d'espèces et Indice de Shannon). La croissance de la végétation et sa disponibilité dans les champs pâturés ont montré à la fin du printemps des différences dans les typologies de gestion des pâturages. Les différentes espèces ruminantes ont influencé significativement les compositions floristiques mais non les mesures de la biodiversité.*

Mots-clés. *Pâturage – Labourage – Gestion du pâturage – Sardaigne.*

I – Introduction

The EU environmental (e.g. Habitat directive) and rural development policies aim to integrate nature and landscape conservation values in agricultural land. Baldock introduced the concept of High Nature Value farmland (HNV), including "hot spots" of biodiversity in rural areas, usually

characterised by extensive farming practice (EEA, 2004). In 2003, European Ministries of Environment agreed to identify all farmland areas with high natural value and to take conservation measures (UN/ECE, 2003). Even if a definitive map of EU HNV still does not exist, preliminary studies show that in Sardinia such areas cover roughly 50% of Utilized Agricultural Area, mostly represented by grazed grasslands and rangelands (AAVV PSR, 2007). The Island is considered an important centre of plant biodiversity. Its flora includes 2400 entities, 5% of which are endemics (Arrigoni, 2006). Mediterranean agro-pastoral systems based on grasslands, mostly managed as pasture and rarely as meadow, are most included in HNV farmland, where plant biodiversity emerge from the interaction between ecological factors and agro-pastoral management. Grazing activities have been associated to the sustenance of biodiversity in different ecosystems, as they are compatible with the maintenance and conservation of a diversity of habitats with high species richness and endemicity (Verdù *et al.*, 2000). However, the natural and agronomic values of grassland vegetation may change in relation to grazing species, stocking rate and grassland management, generating serious environmental issues from both abandonment or overgrazing (Porqueddu and Sulas, 1998; ; Hopkins and Holtz, 2006; Caballero, 2007).

This paper reports preliminary results from the first year of a three-year study focused on the dynamic relationships between contrasting management systems, grassland agronomic value and biodiversity in a Mediterranean context. The field survey was focused on effects of the grazing animal species (cattle *vs* sheep) and on different grassland management strategies (short, medium and long rotation with forage crops).

II – Materials and methods

The study area is located in north-eastern Sardinia (Berchidda) on granite substrate at 250-300 m a.s.l. and it was chosen within the same "environmental unit" as defined by Blasi *et al.*, (2000). The potential vegetation was represented by neutro-acidophylous Cork-oak meso-woods belonging to the association *Violo dehnhardtii-Quercetum suberis* (Bacchetta *et al.*, 2009). In this area, two grazing system typologies (GS) were monitored in 2008-09 (three farms each): cattle and dairy sheep. All farms can be considered representative of the Mediterranean large scale feeding systems based on grazing, supplemented with hay and concentrates during forage shortage period in autumn, winter and summer. The survey was designed to compare within each farm three different types of grassland management (GM), in relation to the number of years from the last crop establishment (tillage, fertilisation, seeding with forage crops): long rotation, more than 20 years (A); medium rotation, 5 to 10 years (B); short rotation, 2 years (C). The experimental design is unbalanced as in some farms it was not possible to identify all types of grasslands. Overall, fourteen fields were sampled in six farms.

In winter 2009, three grazing exclosure cages (20 m^2) were randomly positioned in each field. During spring 2009 (four dates) herbage was sampled with a handheld electric grass mower to simulate grazing at 2-3 cm on a strip of 0.1 x 5.0 m inside and outside the exclosure cages to measure ungrazed herbage mass (Hm) and grazed herbage on offer (Ho) respectively. In one occasion during the grassland vegetative period forage samples collected inside the cages were partitioned to assess the dry matter (DM) contribution of grasses, legumes, composite and other botanic families. In May, a flora's survey was carried out at 50 vertical point quadrats along a 10 m linear transect within each cage (Daget and Poissonet, 1969). From these data, Species Richness (S) and Shannon's Index (H') (Shannon and Weaver, 1949) as plant biodiversity indicators were calculated. Forage DM production and botanical composition were analysed with SAS statistic software using GLM ANOVA procedure within each sampling date. Percentages were transformed in arcsin values; Hm, Ho, S and H' in log values because of a strong correlation between means and variances. An unbalanced CRD split plot design with main plots represented by grazing system typology and subplots by grassland types was performed.

III – Results and discussion

Grass Hm was always below 1 t DM ha^{-1}. The pattern of Hm and Ho showed an increasing trend in spring, typical of the Mediterranean environment, with significant differences between GM only in late spring. Type C grasslands showed a significantly higher Hm on the 4th May and a significantly higher Ho on the 25th May when compared to type A and B (Fig. 1). This result was attributed to the residual effects of the agronomic practices deserved to the preceding sown forage crop in type C grasslands, such as mineral fertilisation or self reseeding of sown species (as Italian ryegrass and subclover) but also to different grazing management.

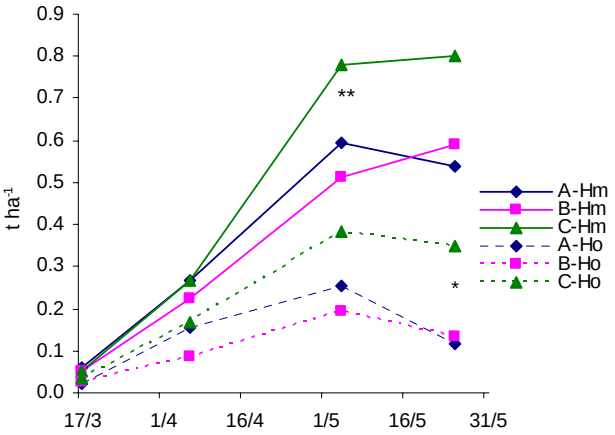

Fig. 1. Hm and Ho patterns (t DM ha^{-1}) in spring in study areas. ** and *= means differ significantly respectively at p <0.01 and p <0.05. Statistical analysis was performed separately for Hm and Ho in each date.

The botanical composition showed a good balance between a main floristic groups. Legumes and grasses represent more than 60% of the forage produced by grassland. The proportion of legumes, grasses and composite was not significantly influenced by GS and GM (Table 1). However, the proportion of others families was significantly higher in cattle than in sheep farms ($p < 0.005$). This result could be explained with the different grazing behaviour of the two animal species. The small animals generally require more energy relative to their gut capacity than large animals and have to select higher quality food (Rook *et al.*, 2004). Sheep in fact are more selective feeders than cattle, having a greater ability to select high quality plant parts also from a less attractive species. This may explain the low incidence of other families as a percentage of total Ho in pasture grazed by sheep. Species Richness and Shannon's Index values evidenced a relatively high plant diversity of these pastures, but they were not significantly influenced by the grazing system and soil management types.

IV – Conclusion

The preliminary data pointed out that Species Richness, Shannon Index and productivity of grasslands were little influenced by contrasting grazing systems and soil management types. The level of plant diversity and the balance between grass and legumes indicate a potential for increasing productivity of these oligotrophic grasslands through agronomic practices and rational grazing management. The botanical composition of these grasslands and the stability of

the biodiversity indexes across contrasting GS and GM can be interpreted as an outcome of ecological constraints (e.g. soil fertility) which may have flattened the response to different anthropic pressures, but also as an indicator of resilience of the Sardinian grassland communities. The results gained in the first year will address the ongoing research to investigate the complex relationships between a range of anthropic and ecological factors influencing the space and time variation of pasture quality and biodiversity.

Table 1. Main floristic groups (%), Species Richness (S) (n) and Shannon's Index (H') of grasslands

	Legumes	Grasses	Composite	Other families	S	H'
GS						
Sheep	37	42	15	6	107	2.555
Cattle	29	37	11	23	115	2.675
P	n.s.	n.s.	n.s.	0.005	n.s.	n.s.
GM						
A	32	45	12	11	105	2.543
B	29	34	14	23	111	2.608
C	38	39	13	11	118	2.695
P	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
GS x GM	n.s.	0.07	n.s.	n.s.	n.s.	n.s.

n.s. = not significant; GS = grazing system; GM = grassland management.

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